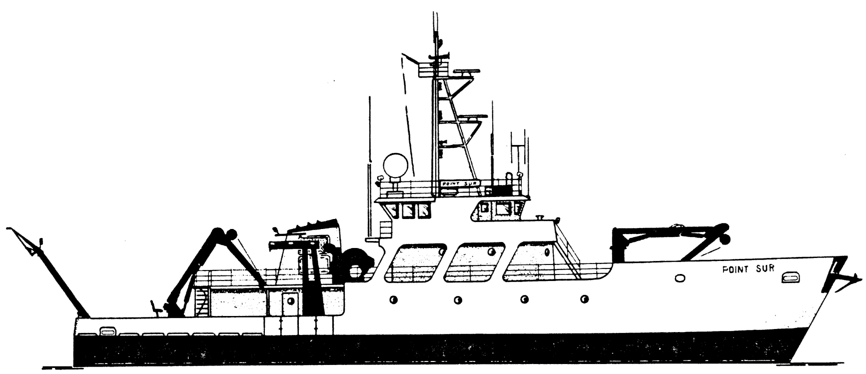
Evaluation of Ship's Envelope Influence on Wind using Observations from R/V PT SUR



Brett S. Martin
LCDR USN
21 March 2002

Operational Oceanography
OC3570
Professor Peter Guest
Professor Curtis Collins

Background and Introduction

My reason for choosing this atmospheric related project was two fold. First, the study of ship's envelope influence on wind has never been more important than it is today. With all of the modern weaponry and radars Naval ships carry, the need for correct wind data has never been greater. The envelope influence can affect wind in such a fashion that military operations may not be able to be carried out due to weapon and radar parameters being out of wind tolerance. Secondly, this project has been attempted a few times before with results that were less than satisfying. I felt I could do a good job on the project and produce relevant results.

In this experiment I wanted to characterize the effect the R/V Point Sur's structure has on wind speed and direction. I accomplished this by taking handheld measurements in 8 different locations throughout the ship (fig1). To collect my measurements I used an AN/PMQ-3 Hand-Held Anemometer (fig 2). Once the data sets were collected, I compared them to true wind speed and direction, relative wind speed and direction, and ship's true heading and speed.

Goals

My goal was simple. I wanted to quantify that where wind measurements are taken does indeed have a direct impact on wind speed and direction. Once I computed my error of hand-held measurements to relative wind, I wanted to show a concise snap shot of the wind error around each station. Once the error was calculated and displayed I could then make good quality suggestion for future studies.

Methodology

To properly use the AN/PMQ-3, you need a location with unobstructed wind flow, and a reference line. When ashore, a field or ramp area with a known true-north reference is ideal. Aboard ship, an unobstructed area of the flight deck or the signal bridge is acceptable. Keep as far away as possible from deck edges, since the eddy effects of wind flowing over the edge of the deck and wind combings will give inaccurate wind speed and direction. It is best to aim the sights of the AN/PMQ-3 toward the bow on a line parallel to the centerline of the ship.

To conduct actual measurements hold the instrument at arm's length and in a vertical position, with the indicator at or slightly above eye level, and align the sights with the true-north reference or the bow of the ship. Depress the vane un-locking trigger to release the wind vane, and at the same time observe the indicated wind speed. Activate the low-speed range-selecting switch on the side of the casing on the newer models, or on the handle of the older models only if the wind speed is less than 15 knots. The indicator will be damaged if the switch is activated during higher winds. Release the vane un-locking trigger when the wind vane yields a representative wind direction, and read the wind direction on the wind vane azimuth circle. All of my wind measurements were based on a running one-minute average.

Ship Locations

Handheld measurements were taken from 8 different locations throughout the ship. The 01 level, where 3 of the measurements were taken (fig 3), is approximately 14.5 feet about the waterline and has a 3.5 feet tall wind combing that surrounds it.

Station 1 is located directly behind the bow and in front of the wildcat. The effect of the wind combing and the wildcat give station 1 a bowl effect. Station 2 is located on the port side of the 01 level just in front of the forward bulkhead of the galley. Station 2 has the wind combing to its left and the Zodiac workboat to its right, creating the potential for the production of the ventury effect. Station 3 is located on the starboard side of the 01 level just in front of the forward bulkhead of the galley. Station 3 has a 10-foot crane to its left and the wind combing to its right, once again creating the potential for the production of the ventury effect.

Station 4 and 5 are located on the port and starboard bridge wings respectively (fig 3). The bridge wing is located approximately 24 feet above the water line. The main characteristic of the bridge wing is that it is surrounded with a solid bulkhead on the inboard side and on the outboard side it has a simple full-length breezeway leading to a 3.5 feet wind combing. The effect of this configuration may lead to a pipe effect.

Station 6 and 7 are located on the main deck on the port and starboard stern (fig 5). The main deck of the fantail is located approximately 4 feet above the waterline and has a 3.5 feet tall wind combing that surrounds it. Station 6 and 7 are both located in the "U" shaped wind combing on the fantail. Station 8 is located on the main deck of the fantail just ahead of the crane arm (fig 4). This station not only gets the effect of the wind combing but also the effect of the structural dimension of the crane arm deflecting the wind.

Ship Produced Data

The ship-produced data came from three locations (fig 5) on the centerline. Relative wind direction and speed data came from a wind measuring set that was located on the center line, 15 feet above the roof of the bridge and approximately 40 feet above the waterline (fig 5). True wind direction and speed came from a measuring set that was located approximately 60 feet above the waterline high upon the mast. The data produce from this measuring set was processed into 2-minute averages. Ships direction and speed came from data provided from GPS. It should be noted that during the time of data collection the Point Sur was for the most part on the same course and speed for each data set and that pitch and roll were not taken into account.

Analysis

For the analysis portion of my study I used 5 complete data sets with each set containing 8 stations each. My goal was to produce 5 charts depicting true wind speed and direction, relative wind speed and direction, handheld measured wind speed and direction, and percent of wind error. To produce the chart I normalized the true wind direction by subtracting out the ships direction from true wind direction. I then normalized the relative wind speed and direction by taking an average of the 8 different wind speeds and directions for each data set. I then plotted both real and relative wind at the top of the chart using arrows that represented the true direction as well as the magnitude of the wind speed. For the handheld observations I depicted them by using the same direction and magnitude arrows. To calculate percent of wind error I divided the handheld wind speed by the relative wind speed and multiplying by 100 and subtracted by 100 to produce an error percentage. Once I came up with a percentage I placed the error next to the corresponding station.

Looking closer at each set of data charts (fig 6 – 10) one can see that in data set 1 (fig 6) Station 1 was under the influence of the bowl effect, while Station 4 was effected by the blocking effect from the port bridge wing which almost completely blocked the wind from the handheld measurement. Data set 2 (fig 7) shows that Station 8 has a large error due to the blocking dimensions of the crane arm and the swirl effect that is produced by the wall configuration in front of the station. Data set 3 (fig 8) shows that once again Station 1 wind has a huge error and is being affected by the bowl effect. Data 4 (fig 10) showed Station 5 having a positive error of + 6% due to the pipeline effect. Both Station 2 and 3 are being affected by the ventury effect producing a fairly high error rate. Data set 5 (fig 10) showed that Station 8 and Station 4 are under the biggest influence of the ship structure.

Conclusions

After completing the analysis of the data it became very clear that where you take your measurements does indeed make a huge difference. When taking the handheld measurements one needs to take into account the ship surroundings. You should take into account such things as the wind combings, equipment dimensions, cove effect, bowl and pipeline effects, and alignment to the bow. This is important because evaporation duct models, weapons, helicopter operations, and many other items all depend on accurate wind measurements for input into their systems. Without accurate wind measurements for input the chance of failure goes up exponentially. A real world example of this can be seen in the Moriah METOC Status Review study of 19 July 1999. In this study two U.S. Naval ships operating in the Persian Gulf were used to compare ships instrument, system utility and reliability as it related to wind data. The conclusions were shocking. The percentage of times when the wind data did not meet selection criteria for the evaporation duct model ran as high 50%. In the after action report it was stressed that further studies of ship effect on data validity needed to be conducted. This could have had grave consequences with the loss of life or unit.

Recommendations for Future Studies

This was a great study for many reason but most of all it was good because it is a real world problem that is very relevant to how we conduct the day to day business of the Navy. I would like to see this study done again but this time with the following items added.

1. Obtain relative winds from the sail data as well as bridge roof measuring set.

2) Take additional handheld measurements on top of the bridge and on the mast.

> * * NOTE: Due to the rough seas and high winds I was unable to obtain these measurements due to safety reasons.

3) Produce a 3D graphic showing how the wind really does flow around the ship.

References

Ross F.R., 1993: Aerographer’s Mate Third Class, NAVEDTRA 12850

Moss Landing Marine Laboratories, 1994: R/V Point Sur Cruise Planning Manual

Davidson, Kenneth, 1999: Moriah METOC Status Review Brief